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SHORT COMMUNICATION

THE USE OF PALMWINE WASTEWATER (Dregs) AS SUBSTRATE FOR THE PRODUCTION OF ELECTRIC CURRENT IN A MICROBIAL FUEL CELL

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ABSTRACT
Yeast inoculum was added to locally made palm wine which served as the substrate for the microbial fuel cell that was constructed purposely with two anode chambers to allow for 4 litres of the substrate, with a single cathode chamber, and the use of a mediator, for electron transfer. After running the system for 2 days, the current was first generated on the second day and had its peak at 3 mA and this was observed for a total of 6 days after which there was a decline in the amount of current produced. On the 18th day there was sharp reduction in the amount of current produced, with no current produced on day 21.

KEYWORDS: microbial fuel cell, palm wine, current.

INTRODUCTION

The quest to generate an alternative and cheap energy source led to this development of the microbial fuel cell (MFC). For many years, crude oil has been the world's major source of energy. Crude oil exploration has come with a lot of environmental problems. Some of the problems associated with crude oil exploration include; gas flaring, land and water pollution. Furthermore the instability in the regions where this crude oil are found has led to constant increase in the price of crude oil in the world market, These problems, and the high level of climate change has led to a constant search for an alternative energy sources that is both cheap and environmentally friendly. Biofuels are one of such alternative source of energy that is both cheap and "clean". Biofuels are generally classified into two; enzymatic fuel cells (EMFs) and microbial fuel cell (MFCS)

A microbial fuel cell is a device that converts chemical energy to electrical energy by the catalytic reaction of microorganisms (Allen and Bennetto, 1993). A typical microbial fuel cell consists of anode and cathode compartments separated by a cation specific membrane. In the anode compartment, fuel is oxidized by micro-organisms, generating electrons and protons. Electrons are transferred to the cathode compartment through an external circuit, and the protons are transferred to the cathode compartment through the membrane. Electrons and protons are consumed in the cathode compartment, combining with oxygen to form water. In general, there are two types of microbial fuel cells: mediator and mediator-less microbial fuel cell. Biological fuel cells take glucose and methanol from food 'scraps, and convert it into hydrogen and food for the bacteria.

In a microbial fuel cell that uses a mediator, most of the microbial cells are electrically inactive, thus the electron transfer from microbial cells to the electrode is facilitated by mediators such as thionine, methyl violate, methyl blue, humic acid and neutral red (Delaney *et al.*, 1984) while a mediator-less microbial fuel cell does not require a mediator but uses electrochemically active bacteria to transfer electrons to the electrode (electrons are carried directly' from the bacterial respiratory enzyme to the electrode). Among the electrochemically active bacteria is *Shewanella putrefaciaes* (Kim *et al.*, 1999),

In the production of electricity by the microorganisms, they consume a substrate under anaerobic conditions to produce carbon (iv) oxide, protons and electrons as described below by Bennetto (1990).

$$C_{12}H_{22}O_{11} + 13H_20 \longrightarrow 12C0_2 + 48H + 48e$$

Microbial fuel cells use inorganic mediators to tap into the electron transport chain of cells and steal the electrons that are produced. The mediator crosses the outer cell lipid membranes and plasma wall; it then begins to liberate electrons from the electron transport chain that would normally be taken by oxygen or other intermediates. The now reduced mediator exits the cell wall with electrons that shuttles to an electrode where it deposits them. This electrode becomes the electro-generic anode (negatively charged electrode). The release of the electrons means that the mediator returns to its original oxidized state ready to repeat the process. It is important to note that this can only happen under anaerobic conditions, if oxygen is present, it will collect all the electrons as it has greater electro negativity value than the mediator.

The use of a mediator is necessary since the microorganism in this study is yeast and lacks the ability to self mediate. Palm wine has a high level of glucose thus the rate of reaction is relatively faster than other sources of substrate.

MATERIALS AND METHODS
Waste water/ substrate
Palm wine

Two short section of plastic pipe (PVC)
These served as the salt bridge connecting the cathode chamber to the anode chambers.

Plastic flanges
Served as means of connecting the plastic pipes to bottles

Epoxy
Used as sealing material and the type used was PVC epoxy.

Copper wire
80 cm long copper wire was used to create an external circuit.

Multimeter
This was used to measure voltage and current generated by the microbial fuel cell.

Agar and salt
This was used to make salt bridge which served as the proton selective membrane. The agar used was nutrient agar

Methyl red
Used as a mediator for electron transfer from the inner membrane of the microorganisms to the graphite rods

Graphite rods
They were used in transferring electron to the copper wires down the external circuit.

Distilled water
It was used in pipes and plastics cleaning

Anaerobic kit
Contained powder which where poured in the plastic bottles to keep the anode compartments under anaerobic conditions

Three heavy duty plastic bottles
The plastics where 18cm in height, two of the plastics served as the anode chamber, while the third served as the cathode chamber. The plastics serving as anode chambers had available lids

EXPERIMENTAL SET-UP
Materials where collected, then caps of flanges where connected to the bottles, using epoxy to glue and allowed to dry.

The salt bridge was assembled by dissolving nutrient agar in boiling water (at concentration of 100g/L). Thus, the nutrient agar was dissolved in a boiling water and salt added to the nutrient agar while still hot to obtained the salt bridge assemblage

The plastic pipes (PVC) where cleaned using distilled water, and sealed at one end, then the agar/salt mixture was poured into the plastics while still hot. Once in the plastic, they were allowed to solidify by placing in a refrigerator.

Electrodes where assembled by connecting copper wires to the graphite rods. The microbial fuel cell was assembled by connecting the salt bridge between the three plastics bottle as shown in figure1, and by connection of the copper through the plastic bottle to the multi-meter instrument.

The inoculums (wastewater) was then added to the anode compartments, while a conductive solution made up of salt and water was added to the cathode chambers. Anaerobic powder was added to the anode chambers. The graphite in the anode compartments where dipped into solution of methyl red, and the anode chamber closed, while the cathode chamber was left open. The microbial fuel cell was allowed to run for a period of 21days. After using 4litres of the substrate (inoculum), the current reading was taking continuously using the multi-meter.

RESULTS

Fig 1: The experimental setup.

Table 1 shows the various days and the average current generated on each day were shown. The current generated was measured and recorded in seconds, and had a steady rise until the eight day. It has its peaks for six days, then started to decline until the twentieth day. No current was recorded at the last day. The maximum current was 0.3mA

Table 1: Various days and the average current generated on each day

DAY	CURRENT(mA)
1	-
2	0.01
3	0.16
4	0.18
5	0.23
6	0.26
7	0.28
8	0.30
9	0.30
10	0.30
11	0.30
12	0.30
13	0.30
14	0.28
15	0.24
16	0.19
17	0.14
18	0.09
19	0.04
20	0.01
21	-

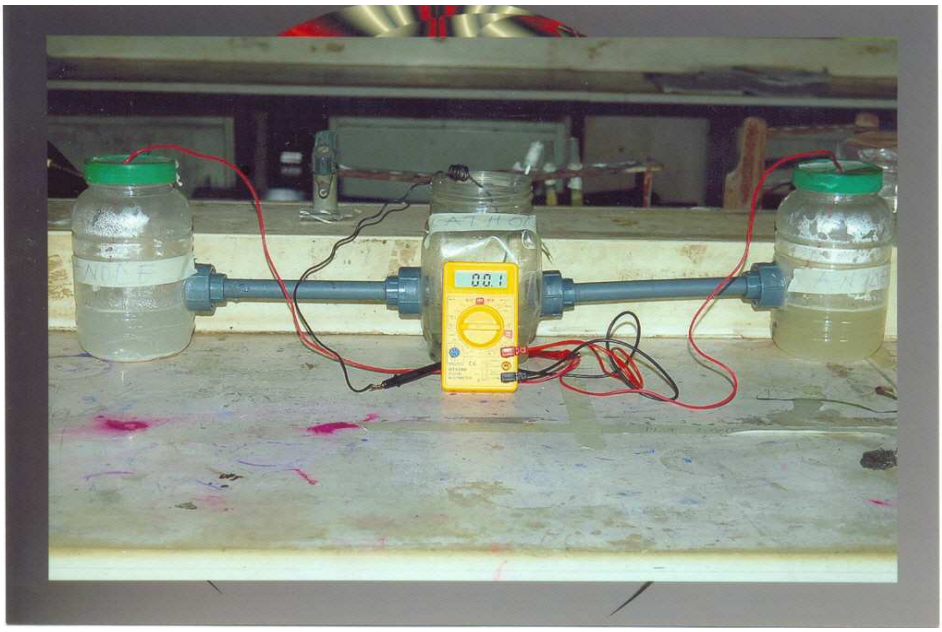

Fig1: showing the designed microbial fuel cell with two electrode chambers.

DISCUSSION

The result showed that it is possible to generate, a measureable current using palm wine dreg as waste water substrate in a microbial fuel cell, after a incubation period of 24h. This may be attributed to the ability of the yeast contained in the dregs to anaerobically degraded glucose moieties and release electrons. The high concentration of glucose in the palm wine dreg makes it a candidate as a substrate for microbial fuel cell design and development for the generation of electricity. The study has shown that the generation of electricity in large scale is feasible using the local raw material palm wine dreg as source of electrons.

REFERENCE

Allen, R.M. and Bennetto, H.P. 1993, Microbial fuel cells—Electricity production from carbohydrates. *Appl. Biochem. Biotechnol.* 39/40, pp. 27–40

Bennetto, H. P. (1990), Electricity Generation by Micro-organisms -*Biotechnology Education*, 1 (4), pp. 163–168

Bullen, Ra; Arnot, Tc; Lakeman, Jb; Walsh, Biofuel cells and their development 21:11.2006.01.030 Biosensors & bioelectronics

Cohen, B. (1931), The Bacterial Culture as an Electrical Half-Cell, *Journal of Bacteriology*, 21, pp18–19

Chen, T., S.C. Barton, G. Binyamin, Z Gao, Y. Zhang, H.-H. Kim & A. Heller (2001), A miniature biofuel cell. *J. Am. Chem. Soc*. 123:35 8630–8631

Hernandez, M.E. and Newman, D.K. (2001), Extracellular electron transfer. *Cell. Mol. Life Sci*. 58, 1562–1571

Delaney, G.M., Bennetto, H.P., Mason, J.R., Roller, H.D.,Stirling, J.L., and Thurston, C.F. 1984, Electron-transfer coupling in microbial fuel cells: 2. Performance of fuel cells containing selected microorganism-mediator-substrate combinations. *J Chem. Tech. Biotechnol.*, 34B: 13–27.

Jang, J.K. et al. (2004), Construction and operation of a novel mediator- and membrane-less microbial fuel cell. *Process Biochem*. 39, 1007–1012

Karube, I., T. Matasunga, S. Suzuki & S. Tsuru 1977, Biochemical cells utilizing immobilized cells of *Clostridium butyricum Biotechnology and Bioengineering* 19 1727–1733 doi=10.1002/bit.260191112

Kim, B.H., Kim, H.J., Hyun, M.S., Park, D.H. 1999a, Direct electrode reaction of Fe (III) reducing bacterium, *Shewanella putrefacience*. *J Microbiol. Biotechnol.* 9:127–131

Kim BH, Chang IS, Gil GC, Park HS and Kim HJ (2003), "Novel BOD (biological oxygen demand) sensor using mediator-less microbial fuel cell". *Biotechnology Letters* 25: 541-545

Liu, H. et al. (2005), Production of electricity from acetate or butyrate using a single-chamber microbial fuel cell. *Environ. Sci. Technol*. 39, 658–662

^ Lithgow, A.M., Romero, L., Sanchez, I.C., Souto, F.A., and Vega, C.A. 1986, Interception of electron-transport chain in bacteria with hydrophilic redox mediators. *J. Chem. Research*, (S):178–179.

Menicucci, Joseph Anthony Jr., Haluk Beyenal, Enrico Marsili, Raaja Raajan Angathevar Veluchamy, Goksel Demir, and Zbigniew Lewandowski, Sustainable Power Measurement for a Microbial Fuel Cell, AIChE Annual Meeting 2005, Cincinnati, USA

Park, D.H. and Zeikus, J.G. (2000), Electricity generation in microbial fuel cells using neutral red as an electronophore. *Appl. Environ. Microbiol*. 66, 1292–1297

Rabaey, K. *et al.* (2005) Microbial fuel cells: performances and perspectives. In Biofuels for fuel cells: biomass fermentation towards usage in fuel cells

Vandevivere, P. and Verstraete, W. (2001), Environmental applications. In Basic biotechnology (Ratledge, C. and Kristiansen, B., eds), pp. 531–557, Cambridge University Press

Venkata Mohan, S., Veer Raghuvulu, S., Sarma, P.N., 2008d, Biochemical evaluation of bioelectricity production process from anaerobic wastewater treatment in a single chambered microbial fuel cell (MFC) employing glass wool membrane. "*Biosen. Bioelectron.*" 23, 1326–1332.

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